Natural Ventilation Group

CIBSE

Ceiling Fans

CIBSE Education Buildings Group

Webinar

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Ceiling fans: Untapped cooling for a warming climate

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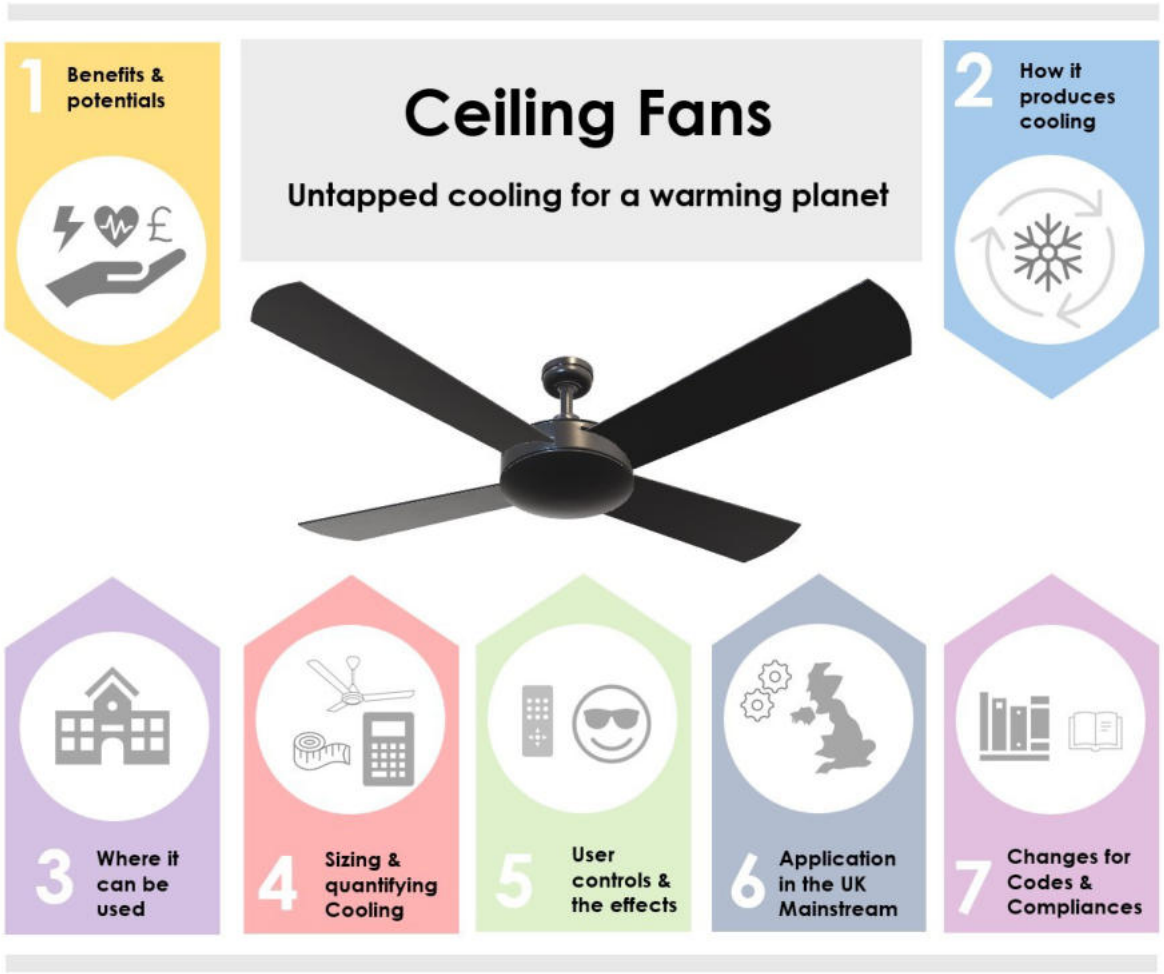
Ceiling fans: Agenda

New CIBSE publication being finalised covering:

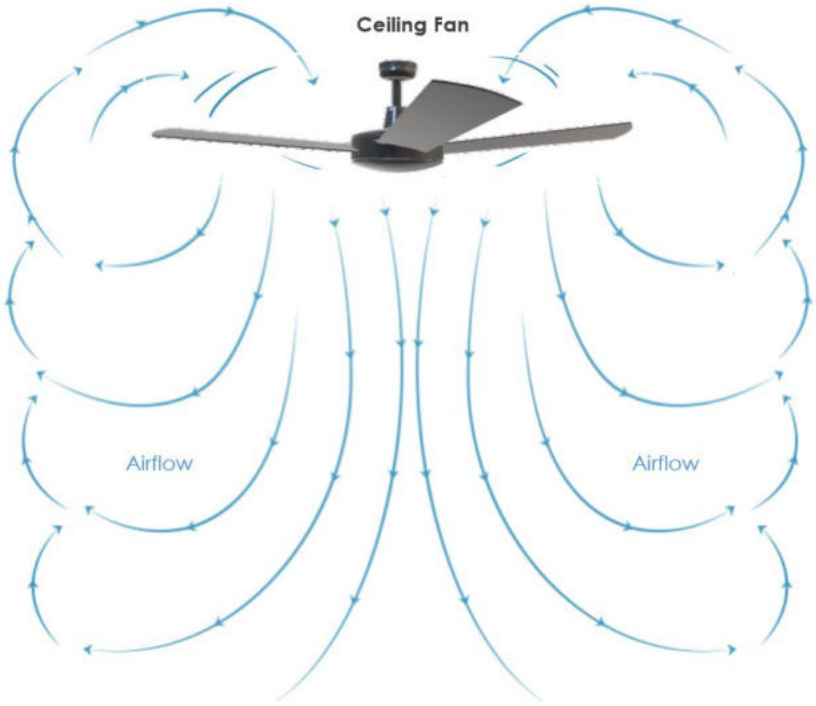
1. Introduction – benefits & potential
2. How ceiling fans produce cooling
3. Where ceiling fans can be used
4. Sizing ceiling fans and quantifying their cooling abilities
5. How different user controls changes the cooling effect
6. Moving ceiling fans into UK mainstream
7. How UK codes and compliance need to change
8. References



An introduction for policymakers, those preparing regulations, wide range of professionals, supply chains & building owners and occupiers

1. Introduction

- Generally overlooked in UK as cooling mechanism
- Planning policy & Building Regulations do not include them as options
- Cooling assessments tend not to include evaporate cooling effects
- Almost no technical guidance for quantifying their cooling effect
- Available technical performance data insufficient



They do not work above 26°C !

They just churn up the air !

1. Introduction

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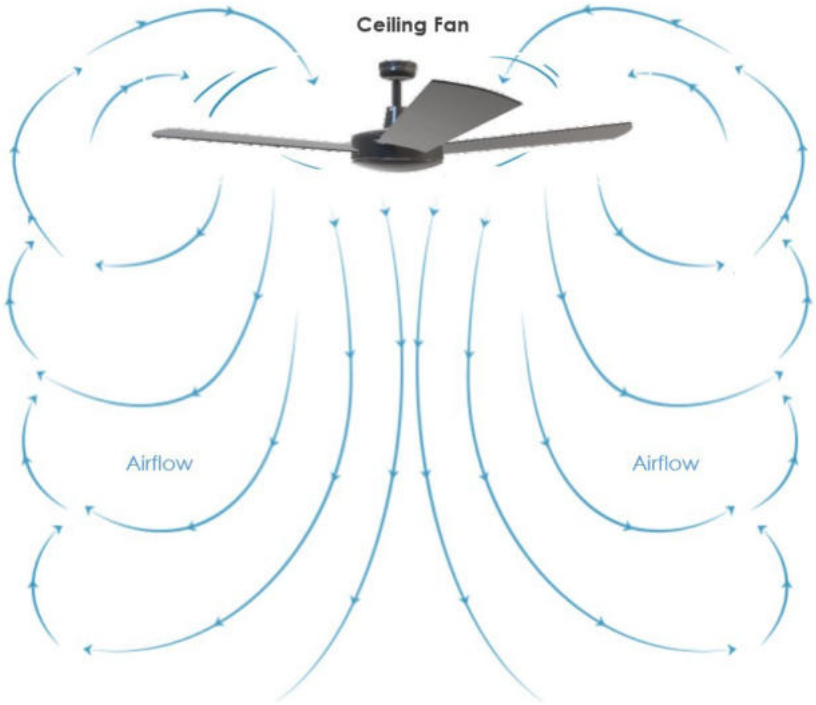
- Learn from where used in regions of the world that are already warmer
- Generally fraction of cost of mechancial cooling
- As much as 90% less energy use, far less embodied carbon
- Far more easily understood by building users

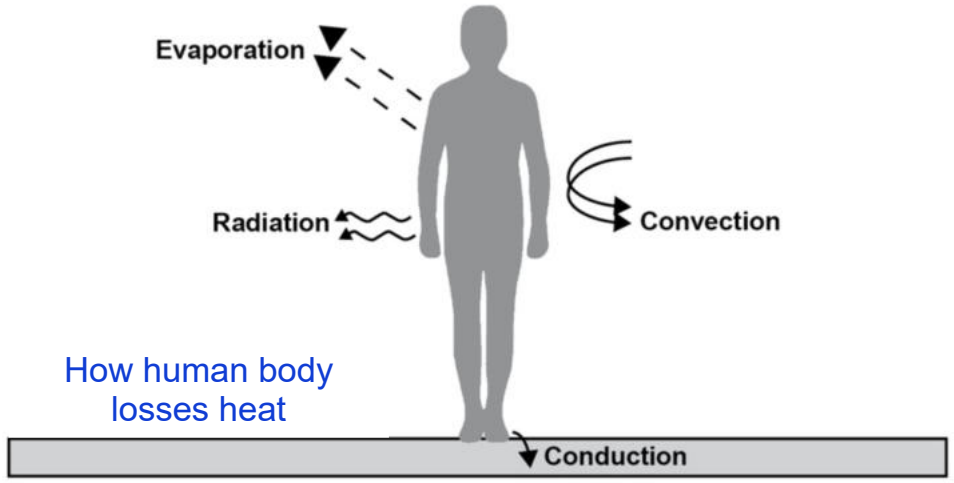


They do not work above 26°C !

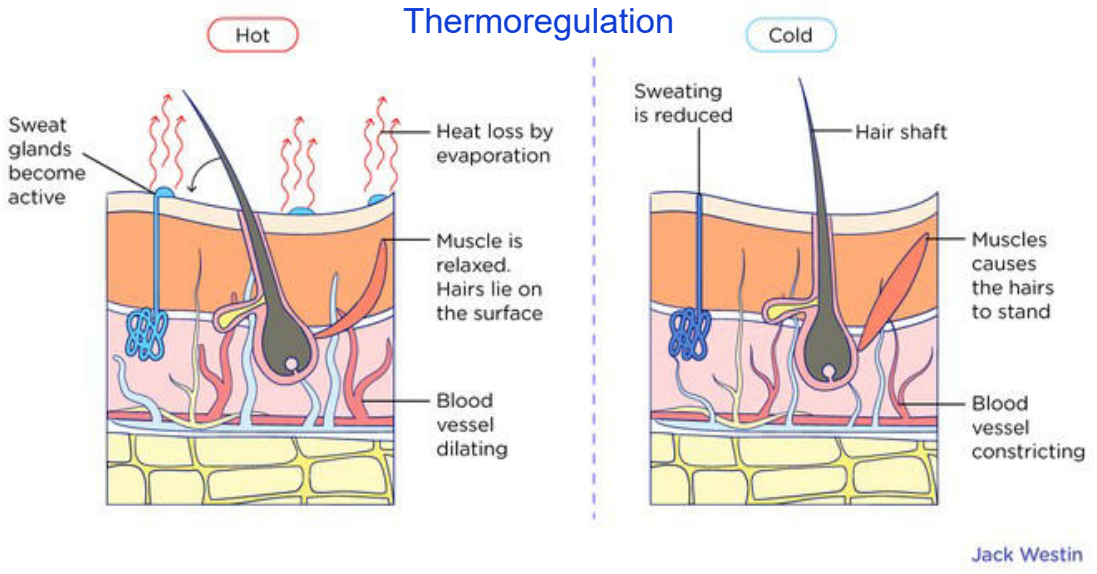
They just churn up the air !

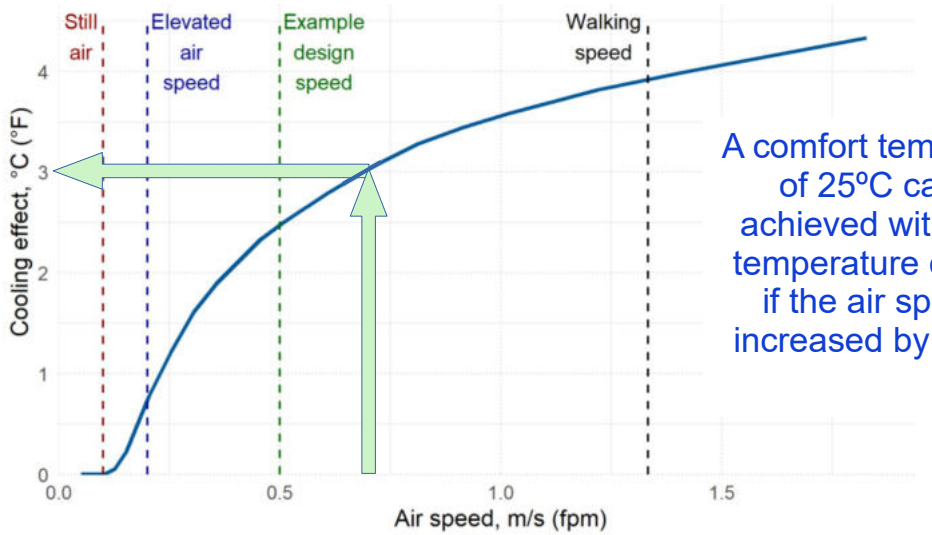
2. How it produces cooling

- Evaporative cooling of the skin
- Varies with air velocity over skin
- It is a comfort cooling mechanism
- Key design factors:
  - mounting height, fan size, speed, noise and control



How human body losses heat





A comfort temperature of 25ºC can be achieved with an air temperature of 28ºC if the air speed is increased by 0.7 m/s

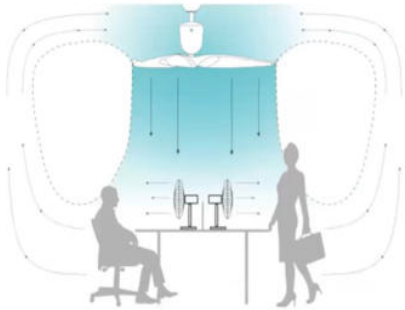
CBE Ceiling Fan Design Guide

Perceptions

Figure 2. Over 90% of surveyed occupants in the Franco Center Apartments rated their indoor environment as comfortable after the ceiling fans were installed. This is an increase in occupant comfort from the earlier survey even though it was 8 °F warmer. Source: Dana Miller.

Can electric fans be safely used during heatwaves? Yes

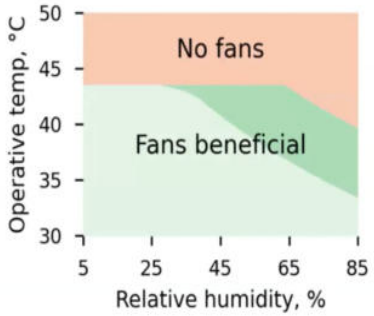
Fans are an effective, affordable, and sustainable cooling technology



Current health guidelines discourage the use of fans at temperatures above 35°C

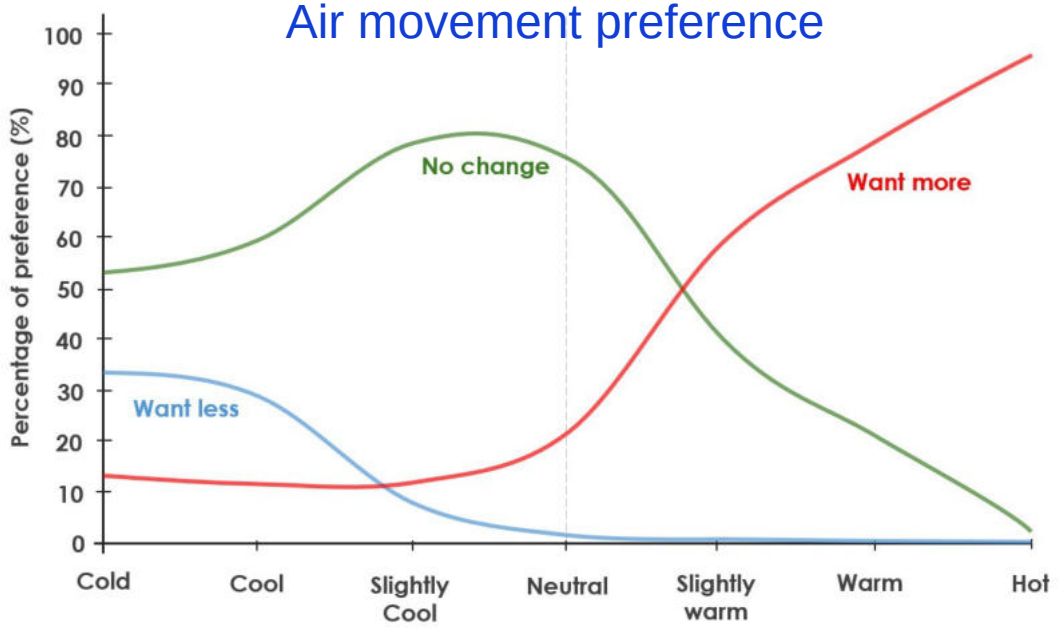
- WHO
- CDC
- EPA
- Ready.gov

Fans can safely be used by healthy individuals in the following conditions



Tartarini, Schiavon, Jay, Arens, and Huizenga (2021) *Building and Environment*

Air movement preference

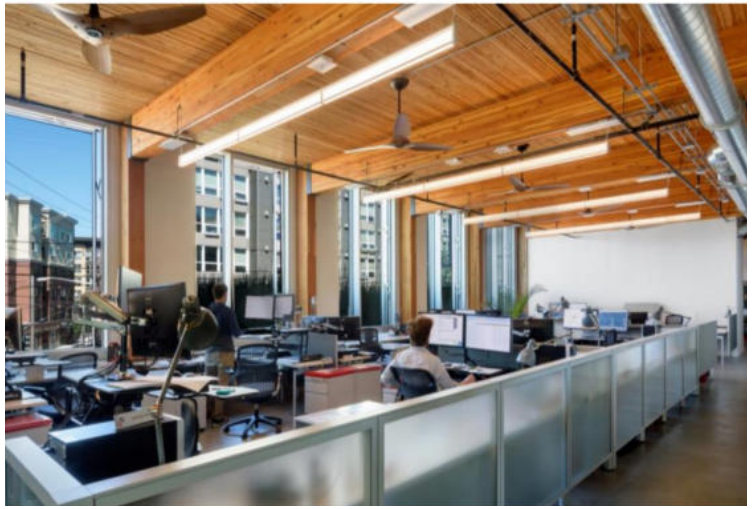


Evolving opportunities for providing thermal comfort, H Zhang, E Arens, UCB, Building Research & Information Jan 2015

3. Applications

Residential – new & retrofit

Education – new & retrofit



Offices – with AC, Mech vent and Nat vent

More applications

Institutional

…..Retail

Transport

…..Recreational

…..Circulation spaces

Outdoors

…..Industrial

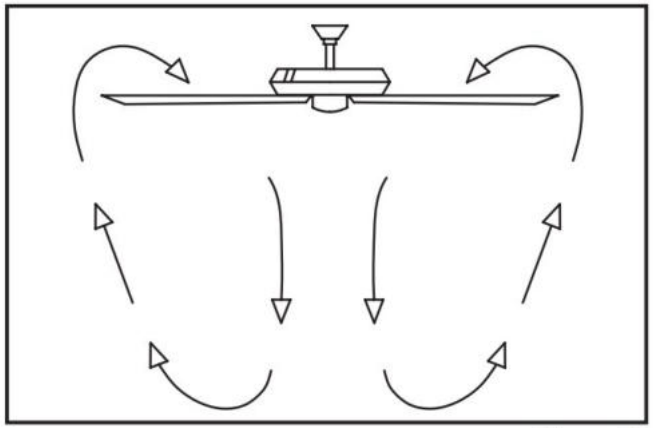
…etc

4. Sizing ceiling fans

Two different approaches recommended:

a) Small scale – single ‘domestic’ sized room

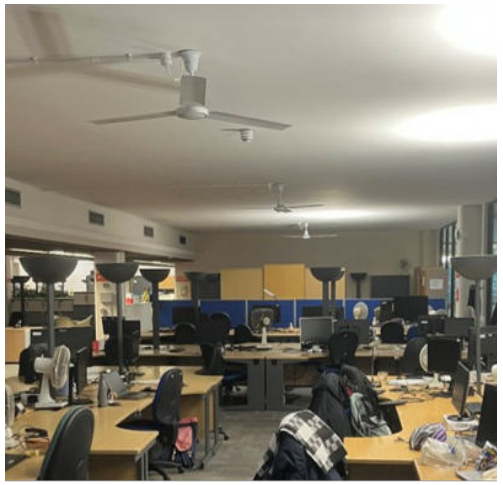
‘Rule of thumb’ deemed to satisfy

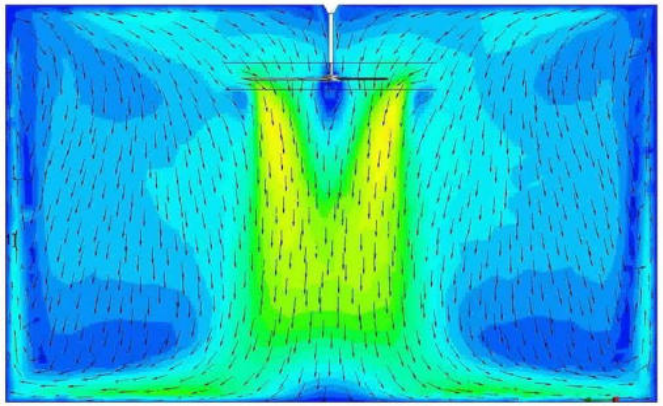


b) Advanced application – quantify cooling effect

Demonstrating code compliance, inc TM59

Larger rooms and multiple fans





Small scale

Rules of thumb

Choosing the right size

Ceiling fan sizes typically span a range from 75cm – 140cm. To determine which size you need, measure the room where the ceiling fan will be installed and follow these guidelines:

Room Dimensions	Suggested Fan Size
Up to 7 m^2	75 – 90 cm
7 - 14 m^2	90 – 110 cm
14 - 22 m^2	110 – 120 cm
22 - 40 m^2	120 – 140 cm

* Reference: American Lighting Association, 2003

Choosing the Appropriate Mounting System

Ceiling fans should be installed, or mounted, in the middle of the room and at least 2.2m above the floor and 45cm from the walls. If ceiling height allows, install the fan 2.4 - 2.7m above the floor for optimal airflow.

- Standard mounts come with a 7.5 – 12.5cm drop-rod, which is the metal pipe that extends from the ceiling bracket to the top of the fan. Drop-rods are usually either 1.25 or 1.5cm in diameter.
- Extended mounts can be used to hang the ceiling fan at the desired 2.4 – 2.7m from the floor for tall ceiling heights. Drop-rods can be purchased from 15cm (2.7m ceiling) to 300cm (6m ceiling). Check with the manufacturer or sales associate to determine the right drop-rod length for you.
- Flush mounts anchor the fan directly against the ceiling. Most standard fans can be installed as a flush mount however, many manufacturers sell “hugger” or “low profile” ceiling fans that are specifically designed for this purpose. Hugger fans are ideal for rooms that have ceilings under 2.4m in height or in situations where a fan with optional light would hang down too low. Hugger fans will not move as much air as a regular fan because the blades are closer to the ceiling.
- Sloped mounts are used for angled or vaulted ceilings.

Ref: US Energy Star

Advanced applications

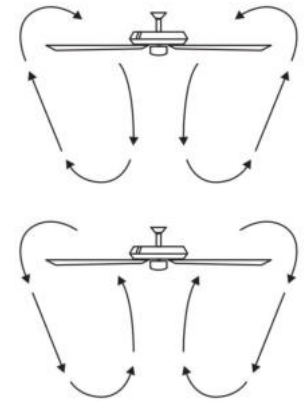
Typically:

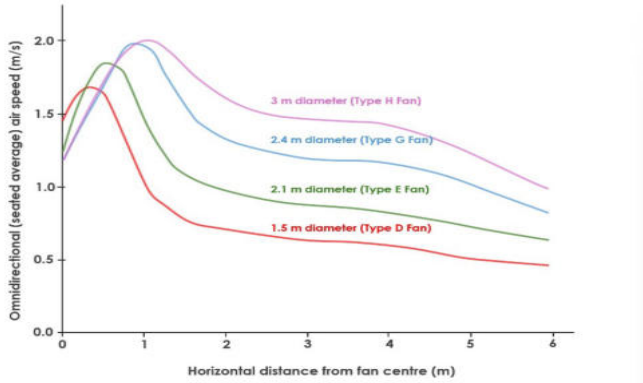
- Predicted Mean Vote (PMV) model
- CBE Thermal Comfort Tool
- Adaptive Comfort Method
- Computational Fluid Dynamics (CFD) simulations

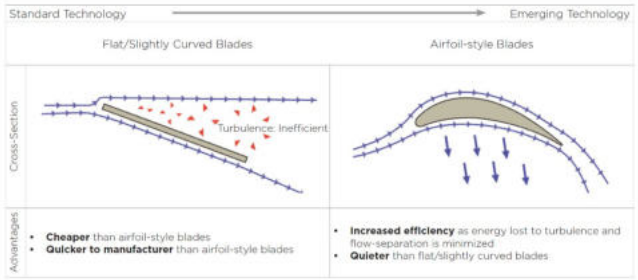
Table 1: Indoor operative temperature correction ($\Delta\theta_o$) (Table B.3 in BSI, 2019)

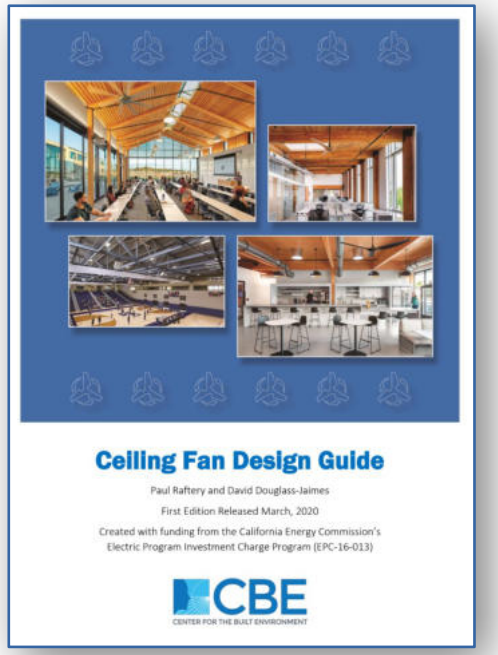
Average air speed (V_a) 0,6 m/s	Average air speed (V_a) 0,9 m/s	Average air speed (V_a) 1,2 m/s
1,2 K	1,8 K	2,2 K

The same table appears in ASHRAE 55 (2017), Table 5.4.2.4, for use with the ASHRAE va of the adaptive model of thermal comfort (see Table 2 below). The associated text says: *"The following effects are already accounted for ....* [in the adaptive thresholds and equations] *..... and therefore it is not required that they be separately evaluated: local thermal discomfort, clothing insulation Icl, metabolic rate, humidity and air speed.'* Also says in Section 5.4.2.4 *'If t_o > 25°C (77°F), then it shall be permitted to increase the upp acceptability temperature limits ..... by the corresponding Δt_o in Table 5.4.2.4'*.



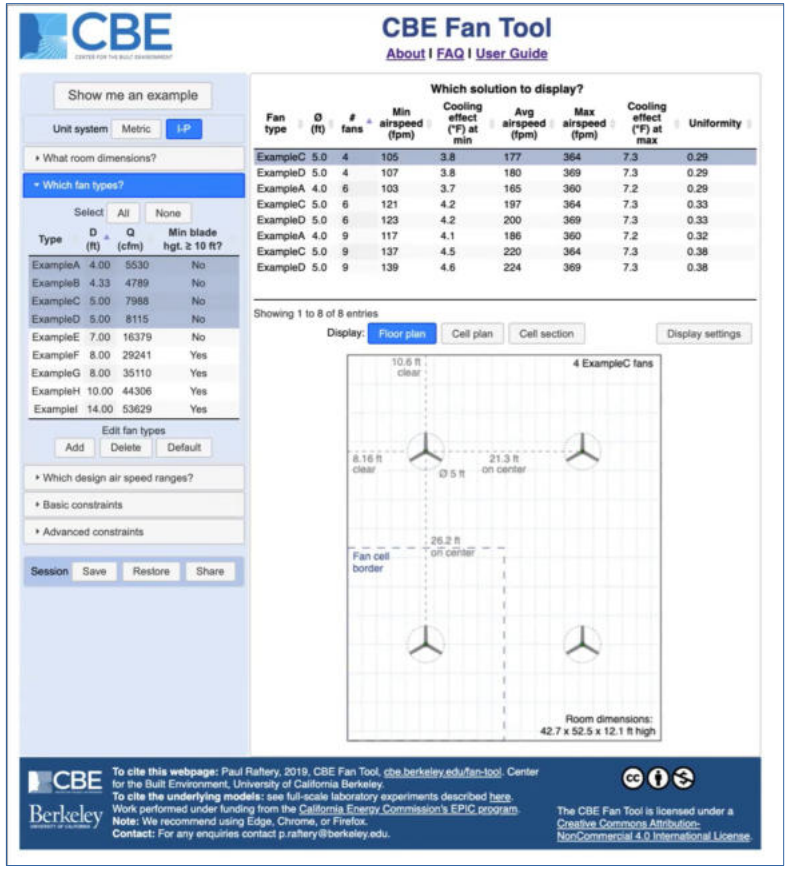


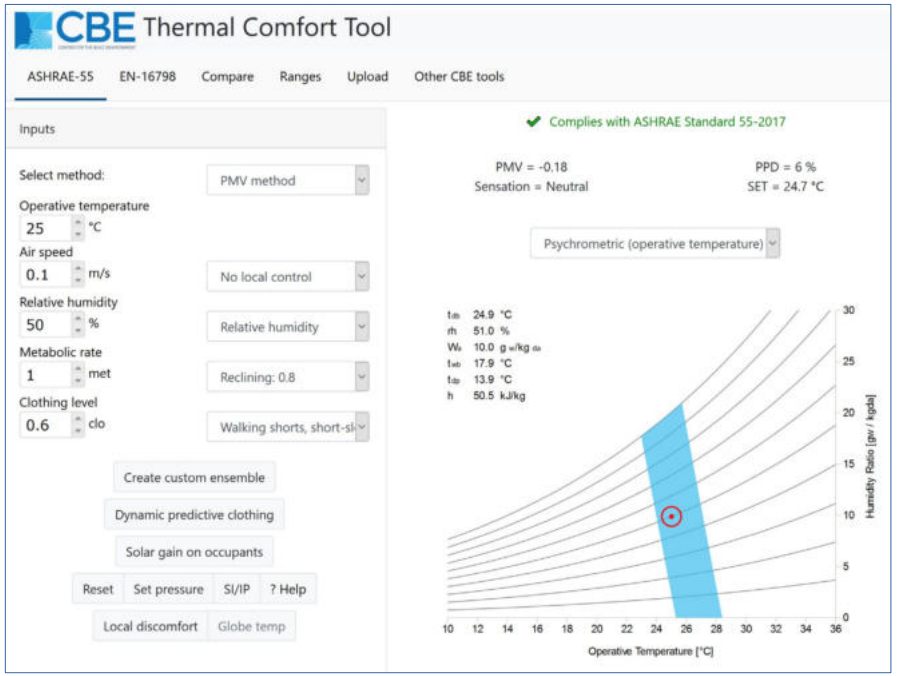




Centre for the Built Environment UCB

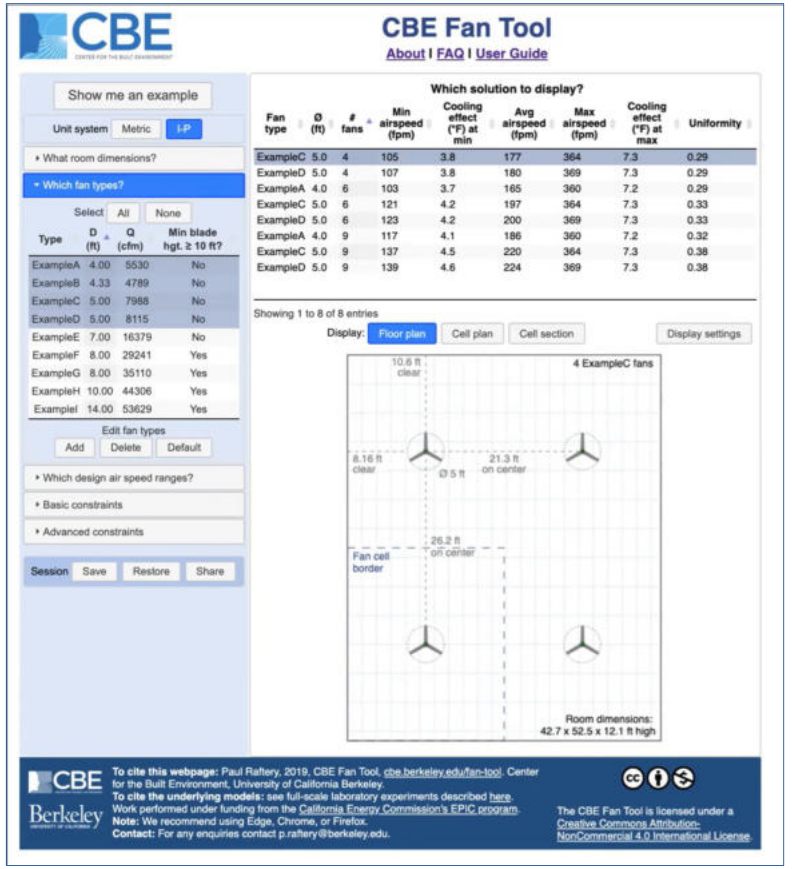
- Predicted Mean Vote model:
  - Mechanical applications
  - NB: TM59 max velocity

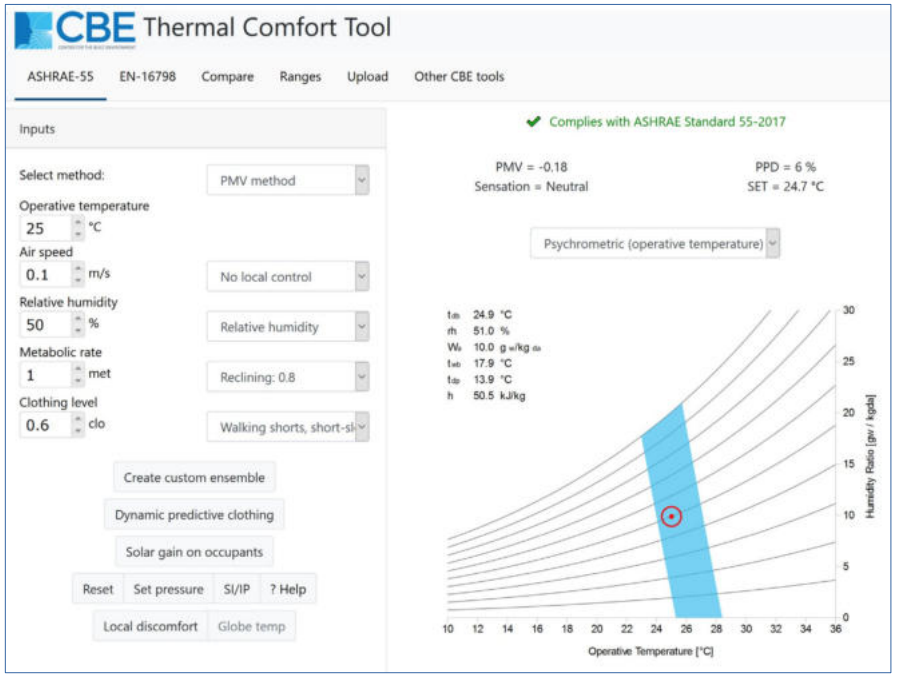




Centre for the Built Environment UCB

- Predicted Mean Vote model:
  - Mechanical applications
  - NB: TM59 max velocity
- Adaptive Comfort Method:
  - Natural vent application
  - Specifies local control
  - NB: simplifications…!
  - No rolling av outdoor temp
  - Presumed baseline air velocity



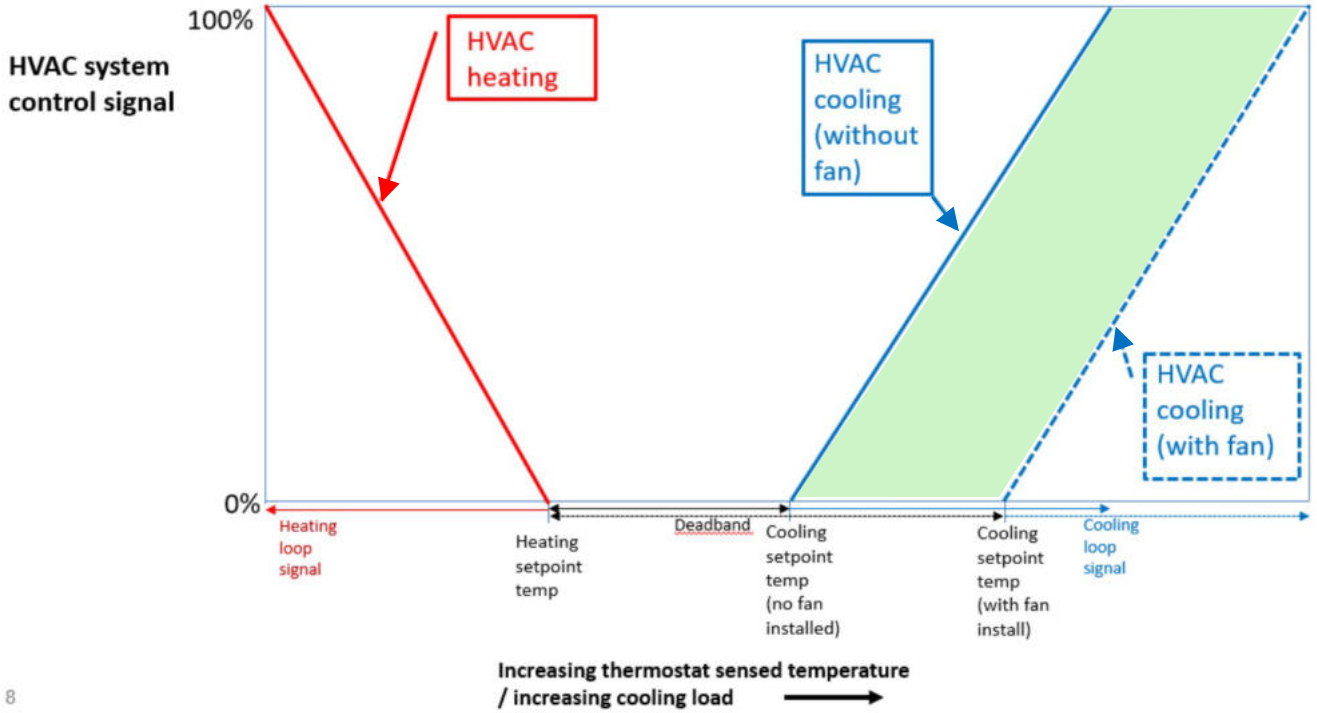


5. Influence of controls

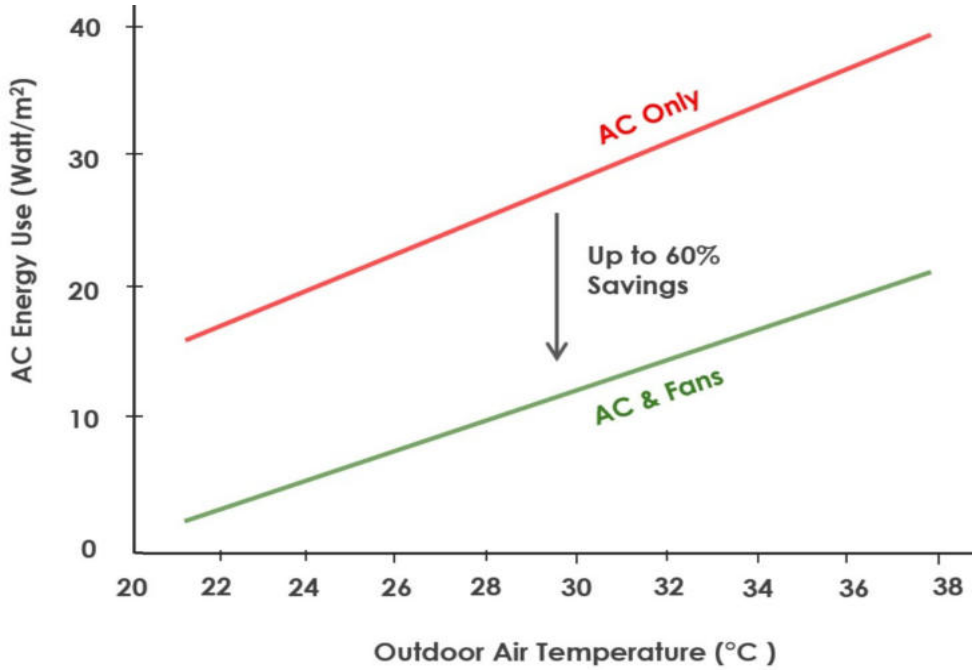
- More cooling potential under individual control – vary local air speed to match level of overheating

Options	Pros	Cons
Local Manual	- User full control and engagement - Simple, flexible operation - Easier to manage fan grouping/zoning	- Energy usage (fans being left on) - Reliance on user engagement for effective operation
Local Automatic	- Useful for areas without user engagement (public areas) - Running time optimised via presence or time control	- More expensive to install - Local manual speed override still required for more finite control - Who manages setpoints etc?
Central Manual	- Useful for areas without user engagement (public areas)	- Room occupants/users feel disempowered. - How is operation managed? Site FM team?
Central Automatic	- Useful for areas without user engagement (public areas) - Running time optimised via presence or time control	- More complexity - Room occupants/users feel disempowered. Local manual speed override still required for more finite control - Who manages setpoints etc?

Controls for Ceiling fans with mechancial systems



Example of HVAC controls logic with / without ceiling fans CBE Guide

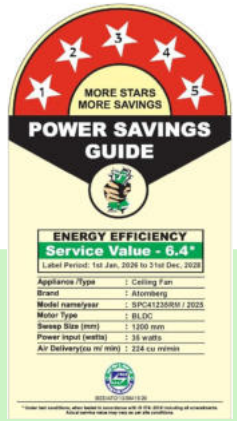


Potential AC energy savings

6. Getting mainstream traction

Currently lacking:

- Technical knowledge
- Fan labelling & specifications
- Regulatory acknowledgement
- Public awareness
- Building confidence



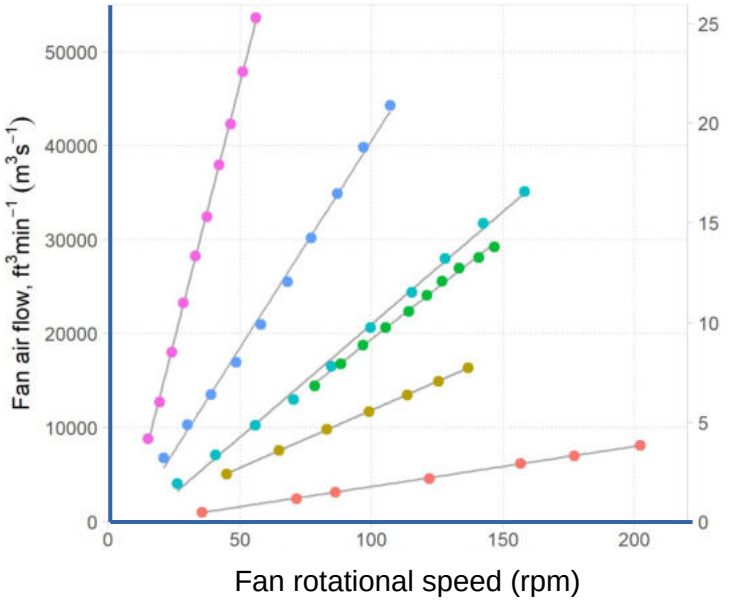
Labelling for Small Scale applications

1. Air flow at the various fan speeds
2. Indicative room-size the fan is suitable for
3. Noise levels, and room-use suitability, for each speed setting
4. Cooling potential for each speed setting (eg: ºC of cooling based on air velocity at 0.9m above floor below fan), to demonstrate regulation or planning policy compliance
5. Power consumed for each speed setting (eg: Watts/m^3/hr)
6. Controls options
7. Installation, operating and maintenance instructions

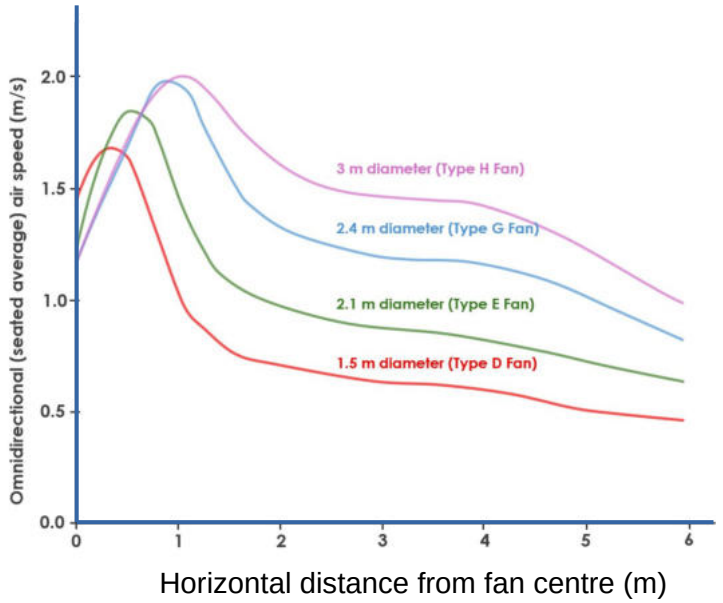
Technical information for Advanced Applications

1. Fan performance curves
2. Acoustics and vibration metrics
3. Energy efficiency data (with aerodynamic data, such as blade design, pitch etc) [Watts/m^3/hr]
4. Air speed in occupied zone and how this changes with fan height and rotation speed.
5. Integration with other systems, such as HVAC, and controls
6. Heat de-stratify potential
7. Installation, operating and maintenance instructions
8. Service life expectations and real-world monitoring data feedback
9. Constituent materials environmental impacts

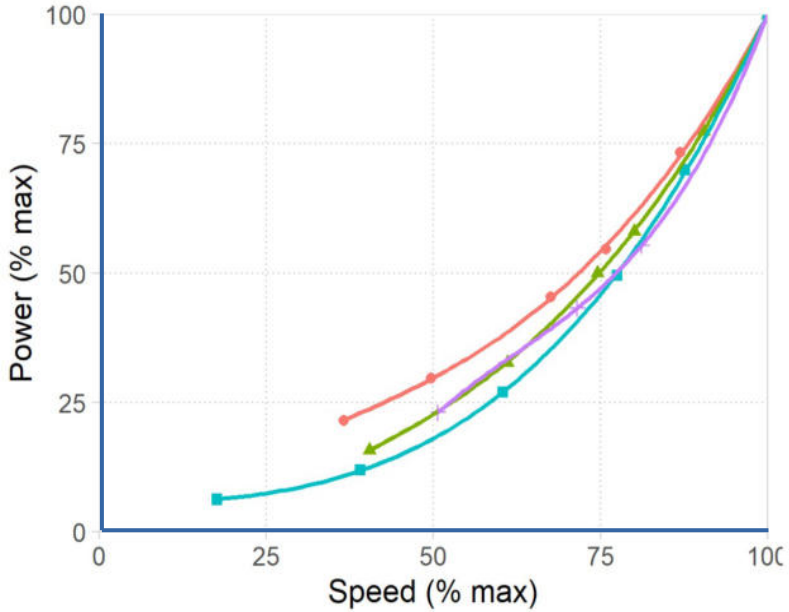
Technical knowledge - Understanding fan performance



Fan speed and air flow
for differing diameter fans



Air speed and distance
for differing diameter fans



Fan power and fan speed
for differing 1.5m fans

Confidence building

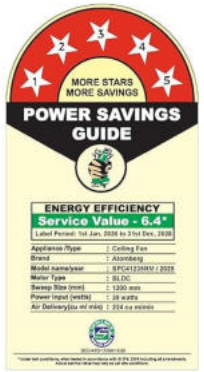
100 - 1500 W
Thousands of $'s

2-30 W
Hundreds of $'s

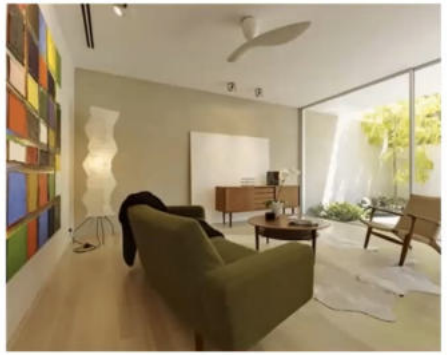
Energy efficient **BLDC motor**

Save upto
₹1500* per year

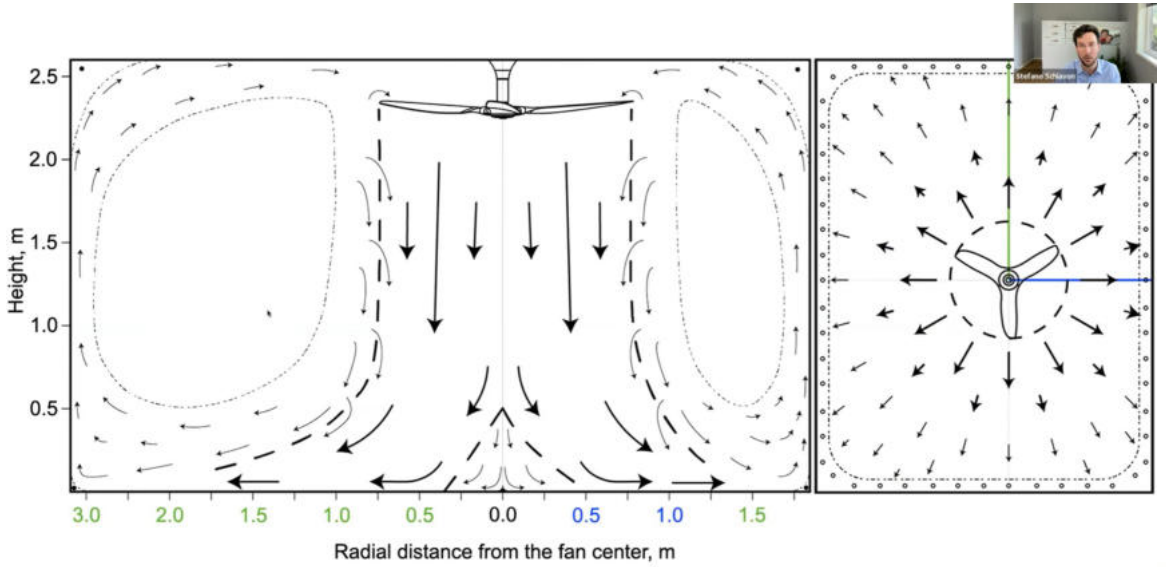
Parameters & Criteria	Unrated Fans	Atomberg BLDC Fans
Wattage	75 W	35 W
Annual Cost of Electricity	₹2880	₹1344
Savings/year	0	*₹1536

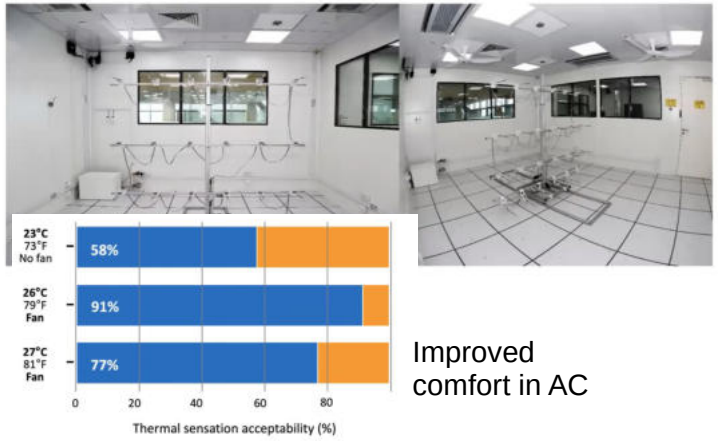


Up to 65% power savings*

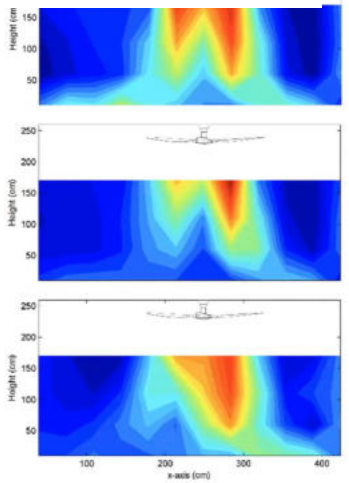


$$Cooling\ Fan\ Efficiency = \frac{Cooling\ effect\ [°C]}{Power\ [W]}$$





Improved comfort in AC



Shuo, Lipczynska, Schiavon, Arens 2018 *Building and Environment* https://cbe-berkeley.shinyapps.io/single-fan

7. Changing Codes & Regulations

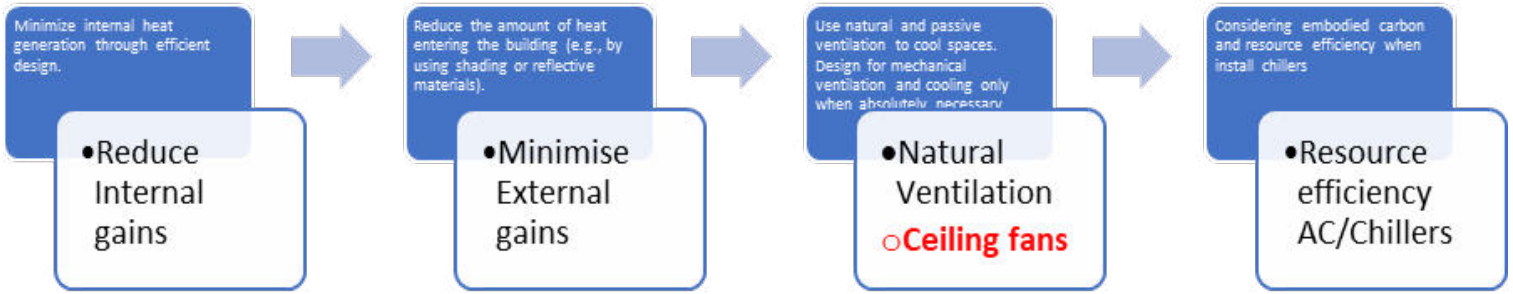
Recommendations for changing UK Regulations and Planning Policy

1. Update the energy **Building Regulations (Part L)** to explicitly include ceiling fan cooling solutions. In practice, this means the energy models (SAP/HEM/SBEM and dynamic simulations) should account for the comfort and energy improvements benefits of in-room evaporative cooling by ceiling fans. Typically these currently use Air or Operative Temperature metrics that do not include evaporative cooling effects.

2. Incorporate ceiling fan solutions into the **Overheating Building Regulations (Part O)**. This would help avoid air conditioning being the current default for noisy development site with limited window opening areas. It would also allow the future climate overheating comfort criteria to be achieved without resorting to mechanical cooling.

3. Enhance **Planning Policy Guidance** – Planning frameworks, like the London Plan's Cooling Hierarchy, should explicitly include ceiling fan evaporative cooling as a solution before resorting ended strategymechanical cooling. By mentioning "use of ceiling fans" in local and national planning guidance, authorities can encourage architects and builders to consider fan installation early in design.

London Plan's Cooling Hierarchy



Ceiling fans – Untapped cooling for a warming climate

In summary:

- Can deliver as much as 4°C comfort cooling for as little as 10% energy use & cost of mechanical alternatives
- Little understood in the UK - technically & more generally
- Regulations and planning policy not supportive

- New CIBSE introduction publication for unlocking potential
- TM59 new revision to include ceiling fans
- CIBSE planning future in-depth UK specific ceiling fans design manual

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